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HEIGHT-WEIGHT SIZING OF PROTECTIVE GARMENTS, BASED ON JAPANESE AIR SELF-DEFENSE FORCE PILOT DATA, WITH FIT-TEST RESULTS

MILTON ALEXANDER
Behavioral Sciences Laboratory

JOHN T. McCONVILLE
Antioch College

JAMES H. KRAMER
Systems Engineering Division

TSGT EUGENE A. FRITZ
Biomedical Laboratory

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BEHAVIORAL SCIENCES LABORATORY
AEROSPACE MEDICAL RESEARCH LABORATORIES
AEROSPACE MEDICAL DIVISION
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FOREWORD

This report was prepared under Project 7184, "Human Performance in Advanced Systems," Task 718408, "Anthropology for Design." It was a joint effort on the part of the Anthropology Branch, Human Engineering Division, Aerospace Medical Research Laboratories, and of Antioch College, Yellow Springs, Ohio. Project scientists were Mr. Milton Alexander for the Anthropology Branch, and Mr. John McConville for Antioch College under Contract AF 33(657)- 9201 and AF 33(616)- 6792.

The work included in this report was carried out under the joint auspices of the United States Air Force, Japanese Air Self-Defense Force and the Military Advisory Assistance Group in Japan. The participation of the USAF team was made possible through the liaison efforts of Dr. Smith W. Ames, Office of the Air Surgeon, Washington. His painstaking efforts throughout the planning stages of the survey and fit-tests are greatly appreciated. Much credit must be given to Major Joseph Davies of the MAAG-Japan office for his assistance during the "setting-up" phase of the initial anthropometric survey conducted in Japan in the winter of 1961. The scheduling for the fit-tests conducted at Hamamatsu and Tachikawa Air Bases was most efficiently arranged by Lt. Col. William F. Magee, MAAG-Japan during the spring of 1963.

The authors wish to extend their appreciation to members of the Japanese Air Self-Defense Force whose cooperation made the entire program possible. Major General Misamitu Oshima and his staff at the Aero Medical Laboratory, Tachikawa, are to be commended for carrying out the anthropometric survey, which was conducted under severe time limitations and trying circumstances. Special thanks are due Major (Dr.) Tadao Fujimoto who played a major role in conducting the survey and the fit-tests, and served as team interpreter for many of the necessary lectures that preceded the actual anthropometric survey and associated fit-tests. Col. Toshiro Hagiwara is especially thanked for the guidance he provided to the team members during the fit-tests of the CSU- 7/P Partial Pressure Assembly and the CWU- 13/P Exposure Suit. The successful completion of the fit-tests are in a large measure due to his liaison work and the efforts of two assistants, Captain Takao Watanabe and 1st Lt. Yoshihisa Yamasaki. Captain Watanabe and Lt. Yamasaki played important parts in the actual "donning and doffing" phase of the fit-tests.

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The authors are deeply indebted to Mr. Edmund Churchill, Anthropology Research Director, Antioch College, for his continuing aid and guidance during the analysis of the data resulting from the fit-tests and the preparation of the report. His special computer routines aided immeasurably in the analysis of the data.

Mr. C. E. Clauser, Assistant Chief of the Anthropology Branch, reviewed the manuscript and suggested improvements for which the authors are indebted. Mrs. Peggy Erskine and Mrs. Demaris McCaslin assisted in the analysis of the data and the preparation of the manuscript.

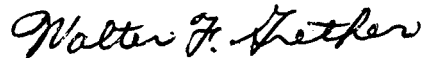
ABSTRACT

This study discusses the development and test of a four-size Height-Weight sizing program of partial pressure and exposure suits designed for the Japanese Air Self-Defense Force. The sizing program is based upon an anthropometric survey of over 200 subjects, conducted at five air bases throughout Japan during the spring of 1961. The statistical rationale used in devising the Height-Weight program is presented along with the analysis of the anthropometric data. Two garments, the CSU - 7/P Partial Pressure Assembly and the CWU - 13/P Exposure Garment, were fabricated in accordance with the developed sizing program. A fit-test of these garments was conducted at Hamamatsu and Tachikawa Air Bases, Japan, in April 1963.

The results of the fit-tests served to validate the soundness of the basic survey data and subsequent development of the Height-Weight sizing program.

PUBLICATION REVIEW

This technical documentary report is approved.



WALTER F. GRETHER
Technical Director
Behavioral Sciences Laboratory

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HEIGHT-WEIGHT SIZING OF PROTECTIVE GARMENTS,
BASED ON JAPANESE AIR SELF-DEFENSE FORCE PILOT DATA,
WITH FIT-TEST RESULTS

INTRODUCTION

During a series of conferences in March 1961, in Tokyo, Japan, the Japanese Air Self-Defense Force (JASDF) made the decision to equip their pilots with the CSU - 4/P Partial Pressure Assembly and related equipment for use in the F-104J weapon system program. The CSU - 4/P Partial Pressure Assembly was developed by the Air Force Systems Command of the United States Air Force, and at the time the conferences were conducted was an operational item. Of course, being a USAF development, the garment was sized in accordance with the eight-size, Height-Weight program as described in reference 2. During the conference period in Tokyo several Japanese males were measured and the dimensional relationships of the Japanese males were found to be sufficiently different from those of the USAF personnel to effectively preclude the use of the USAF sizing system for JASDF personnel. It was then agreed that a modified sizing program would have to be devised to properly fit the JASDF pilots with the CSU - 4/P Partial Pressure Assembly.

JASDF flight surgeons were then assembled, from various bases throughout Japan, and were instructed on the methodology and techniques of measuring the 62 body dimensions that were necessary to the development of an effective Height-Weight sizing program for the Japanese pilot. Within the following eight weeks, the flight surgeons measured 239 Japanese pilots at five bases using the prescribed methods and techniques. This sample represented approximately 20 percent of the flying personnel of the Japanese Air Self-Defense Force.

Upon completion of the body-size survey, the raw body-size data were then forwarded to the Aerospace Medical Research Laboratories. The Anthropology Research Project, Antioch College, analysed the data and subsequently developed a four-size, Height-Weight sizing program for the Japanese flight population (ref. 2). Using the statistics obtained from the developed sizing program, a size range of prototype garments was fabricated.*

* The type designation for the Japanese version of the CSU - 4/P Pressure Suit is CSU - 7/P. There is no difference between the CSU - 4/P and the CSU - 7/P except that the CSU - 7/P is sized in accordance with the Japanese four-size Height-Weight data.

At this point in the program it became necessary to validate the results of the effort. An important step in the development of any clothing item is the fit-test. Here, the success, or failure, of a developmental sizing program is realized. Only then, after this final step, in a long progression of experimentation which begins with the gathering of body dimensions, progresses with transforming the raw data into a usable sizing system, followed by integrating the sizing system into the actual item, can the article be judged from the practical standpoint of how it fits and protects the wearer. Fit-tests were therefore carried out on 75 Japanese pilots, using the newly designed four-size Height-Weight flight garments.

DEVELOPMENT OF A JAPANESE AIR SELF-DEFENSE FORCE HEIGHT-WEIGHT SIZING PROGRAM

The anthropometric data described here were gathered by flight surgeons of the Japanese Air Self-Defense Force during the summer of 1961. The measuring teams were given instructions in the anthropometric techniques used by the Aerospace Medical Research Laboratories, United States Air Force. * A total of 62 body dimensions was measured on 239 Japanese pilots at five air bases throughout Japan (ref. 9).

After completion of the anthropometric survey by the flight surgeons, the body-size data were sent to the Anthropology Branch for analysis. Descriptive statistics for the anthropometry of this sample are given in Table 1. The results of the analysis indicated that the Japanese pilots were lighter and smaller than the USAF flying population (ref. 3) and were significantly different in their body proportions. This difference in proportions was best illustrated by the dimensions of Crotch Height (an approximation of leg length) and Sitting Height (an approximation of trunk length) which, when added together, are very close to the total body length as measured in Height. In the Japanese sample, the arithmetic mean value of Height was approximately equal to the 8th percentile of the USAF sample, whereas the mean Sitting Height value of the Japanese sample was comparable to the 40th percentile of the USAF sample. It would logically follow, then, that the values for Crotch Height and other leg lengths would be less for the Japanese than for the USAF sample. The 50th percentile Crotch Height value for the Japanese pilots was found to be comparable to the 1st percentile value of the USAF sample.

Such differences in body proportions mean that the protective flight garments, sized in accordance with the USAF Height-Weight system, would not adequately fit the Japanese pilots even if the pilot's Height and Weight were to fall within the sizing system of the USAF. The USAF garments would in all likelihood be extremely short and tight in the trunk with excessive length in the appendages, particularly the legs.

Because of the observed differences in the body proportions of the Japanese and USAF pilots, as well as the overall differences in body size indicated by the anthropometry of the two populations, a sizing system for protective flight clothing based upon Japanese body sizes was clearly needed.

* The anthropometric techniques used in this study follow those in references 2 and 3. These publications were made available to the JASDF flight surgeons to be used as guides.

TABLE 1
Descriptive Statistics of the Japanese Sample

	N	Range	Mean (Sex)	S. D. (Sex)	C. V.	Percentiles		
						5th	50th	95th
1. Weight*	239	49.0 - 88.5	61.09 (.39)	6.05 (.28)	9.90	52.2	60.4	71.5
2. Height	239	155.2 - 187.3	166.71 (.31)	4.86 (.22)	2.92	159.2	166.2	175.0
3. Cervicale Ht	223	130.5 - 161.4	140.95 (.32)	4.84 (.23)	3.43	133.1	140.4	149.7
4. Shoulder Ht	210	126.2 - 155.0	136.16 (.31)	4.56 (.22)	3.35	128.5	136.0	144.4
5. Suprasternale Ht	203	124.0 - 152.0	134.58 (.31)	4.47 (.22)	3.32	128.0	134.4	142.7
6. Substernale Ht	234	105.7 - 132.0	116.62 (.27)	4.19 (.19)	3.59	110.3	116.6	123.4
7. Nipple Ht	237	111.2 - 136.2	119.99 (.26)	4.09 (.19)	3.41	113.8	119.8	126.6
8. Elbow Ht	235	95.5 - 118.6	104.49 (.24)	3.71 (.17)	3.55	98.8	104.1	111.0
9. Waist Ht	230	90.0 - 118.0	98.39 (.28)	4.33 (.20)	4.40	91.6	97.8	105.3
10. Crotch Ht	232	66.5 - 87.0	74.35 (.23)	3.54 (.16)	4.76	68.5	74.5	80.8
11. Patella Ht	235	41.0 - 53.5	46.85 (.15)	2.24 (.10)	4.78	43.1	46.8	51.1
12. Sitting Ht	239	80.9 - 98.6	90.63 (.17)	2.66 (.12)	2.94	86.2	90.5	95.0
13. Knee Ht (S)**	178	43.0 - 56.7	48.91 (.17)	2.30 (.12)	4.70	45.4	48.6	53.0
14. Popliteal Ht (S)	216	34.5 - 47.5	39.63 (.14)	2.00 (.10)	5.05	36.4	39.5	42.7
15. Shoulder-Elbow Lgth	207	30.0 - 40.0	34.32 (.11)	1.60 (.08)	4.66	31.9	34.2	37.1
16. Forearm-Hand Lgth	212	39.6 - 51.3	44.24 (.12)	1.77 (.08)	4.00	41.4	44.4	46.7
17. Biacromial Dia	99	32.0 - 41.5	37.34 (.19)	1.90 (.14)	5.09	33.9	37.5	40.7
18. Neck Circ	236	32.2 - 43.0	36.02 (.10)	1.61 (.07)	4.47	33.7	35.9	38.9
19. Shoulder Circ	236	95.0 - 117.0	105.22 (.28)	4.25 (.20)	4.04	98.0	105.0	112.1
20. Chest Circ	239	78.7 - 101.5	87.94 (.25)	3.93 (.18)	4.47	81.9	87.7	94.5
21. Waist Circ	238	62.8 - 96.5	73.35 (.34)	5.21 (.24)	7.10	66.5	72.1	82.6
22. Buttock Circ	239	78.0 - 104.0	89.48 (.25)	3.84 (.18)	4.29	83.0	89.1	95.4
23. Thigh Circ	237	41.0 - 62.0	51.84 (.23)	3.60 (.16)	6.94	46.6	51.5	57.9
24. Lower Thigh Circ	235	32.5 - 44.0	37.26 (.23)	2.11 (.10)	5.66	34.0	37.0	40.8
25. Calf Circ	236	30.6 - 42.0	35.51 (.14)	2.09 (.10)	5.88	31.9	35.4	38.9
26. Ankle Circ	239	19.0 - 26.5	21.55 (.08)	1.20 (.05)	5.57	19.9	21.4	23.8
27. Scye Circ	232	37.0 - 49.5	42.23 (.15)	2.32 (.11)	5.49	38.7	42.0	45.9
28. Axillary Arm Circ	234	23.8 - 36.0	29.38 (.14)	2.16 (.10)	7.35	25.8	29.3	32.5
29. Biceps Circ (F)***	236	26.0 - 36.5	30.07 (.11)	1.74 (.08)	5.79	27.3	30.0	33.0
30. Elbow Circ (F)	208	23.5 - 33.0	28.27 (.11)	1.53 (.08)	5.41	25.8	28.0	30.7
31. Forearm Circ (F)	237	23.0 - 32.5	26.81 (.09)	1.44 (.07)	5.37	24.5	26.7	29.5
32. Wrist Circ	237	15.0 - 19.5	16.47 (.05)	0.75 (.03)	4.55	15.3	16.4	17.7
33. Sleeve Inseam	170	41.0 - 51.0	44.98 (.16)	2.15 (.12)	4.78	41.5	44.9	48.0
34. Sleeve Lgth	138	70.5 - 90.5	80.28 (.28)	3.26 (.20)	4.06	74.9	80.0	84.9

* Weight in kilograms, all other dimensions in centimeters.

** (S) designates seated measurement.

*** (F) designates member flexed for measurement.

TABLE 1 (Cont'd)
Descriptive Statistics of the Japanese Sample

	N	Range	Mean (Sex)	S.D. (Sex)	C.V.	Percentiles		
						5th	50th	95th
35. Anterior Neck Lgth	178	6.0 - 13.0	9.29 (.10)	1.36 (.07)	14.64	6.8	9.4	11.1
36. Posterior Neck Lgth	239	8.0 - 16.0	11.89 (.11)	1.66 (.08)	13.96	8.9	11.8	14.8
37. Shoulder Lgth	152	12.2 - 20.0	15.92 (.12)	1.48 (.08)	9.30	13.3	15.9	18.0
38. Waist Back	237	36.5 - 53.0	44.27 (.18)	2.72 (.12)	6.14	39.7	44.3	48.5
39. Waist Front	107	34.0 - 46.0	39.09 (.24)	2.54 (.17)	6.50	34.8	38.8	42.8
40. Crotch Lgth	235	56.0 - 78.0	67.33 (.29)	4.41 (.20)	6.55	59.6	66.9	74.8
41. Vertical Trunk Circ	234	140.0 - 170.0	155.89 (.38)	5.84 (.27)	3.75	146.3	155.7	165.7
42. Interscye	236	31.5 - 48.0	37.43 (.18)	2.79 (.13)	7.45	32.7	37.2	42.0
43. Interscye Max	180	42.0 - 63.0	50.39 (.27)	3.66 (.19)	7.26	44.0	50.2	55.6
44. Buttock Circ (S)	184	88.5 - 112.5	97.37 (.34)	4.68 (.24)	4.81	89.8	96.6	104.9
45. Knee Circ (S)	235	33.0 - 43.2	37.06 (.14)	2.09 (.10)	5.64	34.0	36.9	40.7
46. Medial Malleolus Ht	178	6.5 - 10.9	8.69 (.06)	0.86 (.04)	9.90	7.1	8.7	9.9
47. Hand Lgth	238	16.4 - 20.6	18.24 (.05)	0.80 (.04)	4.38	16.9	18.2	19.5
48. Hand Breadth at Meta	236	7.4 - 9.9	8.55 (.03)	0.53 (.02)	6.20	7.6	8.5	9.4
49. Hand Circ	232	17.0 - 23.8	21.08 (.08)	1.15 (.05)	5.46	19.0	21.0	22.7
50. Head Lgth	236	16.7 - 21.0	18.62 (.05)	0.77 (.04)	4.14	17.1	18.6	19.8
51. Head Breadth	234	13.9 - 17.4	15.71 (.04)	0.60 (.03)	3.82	14.7	15.6	16.6
52. Bizygomatic Dia	176	12.2 - 15.8	14.24 (.05)	0.63 (.03)	4.42	13.1	14.2	15.2
53. Bigonial Dia	238	10.0 - 13.9	11.74 (.05)	0.76 (.03)	6.47	10.4	11.7	13.0
54. Bitrignon Dia	221	12.0 - 15.7	14.16 (.04)	0.65 (.03)	4.59	13.1	14.1	15.2
55. Nose Lgth	237	4.0 - 6.0	4.92 (.02)	0.33 (.02)	6.71	4.4	4.9	5.4
56. Nose Breadth	236	2.8 - 4.4	3.78 (.02)	0.29 (.01)	7.67	3.2	3.7	4.2
57. Menton-Subnasale	233	6.1 - 9.3	7.28 (.03)	0.49 (.02)	6.73	6.4	7.2	8.0
58. Nasion-Menton	236	10.7 - 13.8	12.03 (.04)	0.58 (.03)	4.82	11.0	12.0	12.9
59. Lip Lgth	238	4.0 - 6.1	5.07 (.03)	0.43 (.02)	8.48	4.4	5.0	5.7
60. Head Circ	239	50.5 - 60.2	56.23 (.09)	1.43 (.06)	2.54	53.9	56.1	58.5
61. Bitrignon Frontal Arc	175	28.5 - 34.8	31.43 (.08)	1.11 (.06)	3.53	29.5	31.5	33.0
62. Bitrignon-Menton Arc	236	28.5 - 35.0	31.78 (.08)	1.21 (.06)	3.81	29.8	31.9	33.5

The initial step in the development of a Japanese sizing program was to determine if the rationale underlying the USAF sizing system was suitable for the Japanese sample. The USAF sizing programs use Height and Weight as key dimensions based upon the finding that control of Height and Weight restrict body-size variability due to the high relationship that most body dimensions have with one or the other of these two key dimensions. To test the suitability of using a Height-Weight sizing program for the Japanese sample, multiple correlation coefficients were computed for each anthropometric measurement with the key dimensions of Height and Weight. The multiple correlation coefficients for both the Japanese and the USAF samples are listed in Table 2. It was apparent from this analysis that the multiple correlations for the Japanese were consistently lower yet preserved relatively the same relationship as were exhibited by the USAF correlation coefficients. Despite the variance between the samples noted in Table 2, it was decided that the Height-Weight technique of sizing would in all probability work as well for the Japanese pilots as it has been shown to be a useful instrument in the sizing of protective flying garments for USAF personnel (ref. 1, 2). A Height-Weight sizing program was therefore developed based upon the anthropometry described above.

The second step in the development of the Japanese Height-Weight sizing program was to prepare a bivariate table of Height and Weight in order to determine from it the distribution of body sizes which must be covered by the sizing categories. This bivariate is illustrated here as Table 3. The distribution of subjects on the Height-Weight bivariate suggests that the population is more homogeneous in body size than the USAF population; as a consequence of this, fewer sizes should be required than are normal for the USAF population. One of the USAF Height-Weight sizing programs that has been used extensively with success is the eight-size program. In this program, each of the eight-size categories contains individuals who are more or less alike with regard to body size, with no member of a category varying more than 4.5 inches in Height and 25 pounds in Weight from any other member.

When this range of variation in Height and Weight for each design group was applied to the Japanese bivariate distribution, it was found that a four-size Height-Weight sizing program would include approximately 95 percent of the distribution. In reality, the four proposed sizes for the Japanese had a slightly different range of variability with 10 cm (3.94 in) of Height and 12 kg (26.4 lbs) of Weight being used for each group. This difference appears minor, and an alternate solution, a six-size program, that would have reduced the number of individuals included in the two heavier design groups to a dozen or fewer, did not seem desirable.

TABLE 2

Multiple Correlation Coefficients

Height and Weight with:	<u>Japanese *</u>	<u>USAF**</u>
3 Cervicale Height	.923	.97
4 Shoulder Height	.908	.95
5 Suprasternale Height	.925	.97
6 Substernale Height	.824	.90
7 Nipple Height	.910	.93
8 Elbow Height	.805	.91
9 Waist Height	.760	.90
10 Crotch Height	.741	.86
11 Patella Height	.708	.82
12 Sitting Height	.750	.74
13 Knee Height (S)	.761	.89
14 Popliteal Height	.651	.80
15 Shoulder-Elbow Length	.680	.73
16 Forearm-Hand Length	.711	.78
17 Biacromial Diameter	.442	.50
18 Neck Circumference	.565	.66
19 Shoulder Circumference	.599	.81
20 Chest Circumference	.687	.84
21 Waist Circumference	.673	.84
22 Buttock Circumference	.718	.90
23 Thigh Circumference	.635	.85
24 Lower Thigh Circumference	.662	.70
25 Calf Circumference	.634	.74
26 Ankle Circumference	.522	.61
27 Scye Circumference	.518	.56
28 Axillary Arm Circumference	.550	.78
29 Biceps Circumference (F)	.604	.78
30 Elbow Circumference (F)	.499	.60
31 Forearm Circumference (F)	.578	.74
32 Wrist Circumference	.596	.58
33 Sleeve Inseam	.537	.63
34 Sleeve Length	.621	.73
35 Anterior Neck Length	.437	.46
36 Posterior Neck Length	.130	.27
37 Shoulder Length	.244	.36
38 Waist Back	.378	.56
39 Waist Front	.332	.54
40 Crotch Length	.402	.59
41 Vertical Trunk Circumference	.579	.82
42 Interscye	.298	.48
43 Interscye Maximum	.272	.55
44 Buttock Circumference (S)	.676	.87
45 Knee Circumference (S)	.641	.81
46 Medial Malleolus Height	.416	.45

* The N's for this sample are given in Table 1.

** Sample size equals 1000.

TABLE 3
Height-Weight Bivariate Table of 239 Japanese Pilots

	154- 155.9	156- 157.9	158- 159.9	160- 161.9	162- 163.9	164- 165.9	166- 167.9	168- 169.9	170- 171.9	172- 173.9	174- 175.9	176- 177.9	178- 179.9	180- 181.9	182- 183.9	184- 185.9	186- 187.9	Totals
88-89.9																		1
86-87.9																		
84-85.9																		
82-83.9																		
80-81.9						1					1			1				3
78-79.9																		
76-77.9							1											
74-75.9							2											2
72-73.9			1				2						1					5
70-71.9				1		1		3										8
68-69.9					1		2	1	1	3			2	1				11
66-67.9				1		1	3	4	1	1		1						13
64-65.9			1	2	4	3	4		3	1	4	1				1		24
62-63.9		1	1	1	4	2	6	4	4	2	1	1						26
60-61.9		1	3	3	6	7	9	2	8	4	1							41
58-59.9				2	1	14	4	9	3		1							34
56-57.9			1	6	8		5	2	3	1								26
54-55.9			1	3	4	2	5	1	1	1								23
52-53.9			1	3	1	2	3	1										14
50-51.9	1			4	1													6
48-49.9		1																1
Totals	1	3	11	25	29	37	47	27	28	13	8	6	1	2	0	0	1	239

$r = .429$

The four-size program selected included the following ranges of Height-Weight variability:

<u>Size Category</u>	<u>Weight (kg)</u>	<u>Height (cm)</u>	<u>N</u>	<u>Percent</u>
Small Regular	50.0 - 61.9	156.0 - 165.9	79	33.0
Small Long	50.0 - 61.9	166.0 - 175.9	64	26.8
Large Regular	62.0 - 73.9	158.0 - 167.9	41	17.2
Large Long	62.0 - 73.9	168.0 - 177.9	43	18.0
Outside Design Ranges			12	5.0
			239	100.0

Each of the size categories was then treated as a separate sample with means and standard deviations being computed for each of the anthropometric variables.* The results of these computations are given in Table 4.

From these values the design ranges of each variable were calculated for the four-size categories. These design values give the range of variability for each anthropometric dimension that must be considered by the designer in the fabrication of the protective garments. The design range, consisting of a minimum and a maximum value, was calculated from the category mean. The minimum was obtained by subtracting from the mean a value equal to one-and-one-half times the average standard deviation of the four-size categories for a particular variable. The maximum was obtained by adding an equal value to the mean. This composite origin for the within-a-size standard deviation was used to achieve sampling stability. Variable 20, Chest Circumference, would have a within-a-size standard deviation of 3.01 cm and this number times one-and-one-half would be added to, and subtracted from, each of the four-size category mean values to obtain the design range of Chest Circumference. The Chest Circumference design range of the small-regular size would be 81.5 - 90.5 cm. The use of one-and-one-half within-a-size standard deviations plus and minus the four average values includes some 87 percent of all the values that make up each subsample. This is the same technique employed in developing the Height-Weight sizing system used in the sizing of USAF protective gear.

The minimum and maximum design values thus calculated for each variable and Height-Weight category are given in Table 5.

* Only 46 of the 62 variables were treated in this analysis. The 16 variables not treated were measurements of the head and hands for which new protective gear was not required.

TABLE 4

Means and Standard Deviations of Height-Weight Categories

<u>1. Weight *</u>	<u>N</u>	<u>\bar{X}</u>	<u>S. D.</u>	<u>2. Height</u>	<u>N</u>	<u>\bar{X}</u>	<u>S. D.</u>
Sml Reg	79	56.68	3.05		79	162.64	2.29
Sml Lg	64	58.37	2.60		64	169.00	2.42
Lrg Reg	41	65.46	2.98		41	164.44	2.60
Lrg Lg	43	66.29	3.22		43	171.91	2.77
<u>3. Cervicale Ht</u>				<u>4. Shoulder Ht</u>			
Sml Reg	76	137.26	3.08		70	132.65	3.00
Sml Lg	57	143.19	2.85		55	138.04	2.70
Lrg Reg	39	139.28	2.77		37	134.70	2.52
Lrg Lg	40	145.60	3.68		36	140.24	3.04
<u>5. Suprasternale Ht</u>				<u>6. Substernale Ht</u>			
Sml Reg	67	131.12	2.37		77	113.78	2.72
Sml Lg	54	136.56	2.90		63	117.74	3.24
Lrg Reg	36	132.82	2.62		39	115.93	3.23
Lrg Lg	35	139.11	3.18		43	120.06	3.20
<u>7. Nipple Ht</u>				<u>8. Elbow Ht</u>			
Sml Reg	78	116.80	2.02		79	101.88	2.54
Sml Lg	63	121.92	2.89		63	105.83	2.61
Lrg Reg	41	118.27	2.97		40	103.55	2.11
Lrg Lg	43	123.68	2.62		41	107.67	2.91
<u>9. Waist Ht</u>				<u>10. Crotch Ht</u>			
Sml Reg	76	95.37	2.60		77	72.33	2.47
Sml Lg	62	100.24	3.25		62	75.70	2.74
Lrg Reg	39	96.86	2.92		39	72.76	3.09
Lrg Lg	41	102.01	3.60		42	77.10	2.84
<u>11. Patella Ht</u>				<u>12. Sitting Ht</u>			
Sml Reg	76	45.57	1.76		79	88.80	2.16
Sml Lg	63	47.32	1.86		64	91.62	2.03
Lrg Reg	41	46.12	1.38		41	90.22	1.96
Lrg Lg	43	48.78	1.77		43	92.74	2.08

* Weight in kilograms, other dimensions in centimeters.

TABLE 4 (Cont'd)

Means and Standard Deviations of Height-Weight Categories

<u>13. Knee Ht (S)**</u>	<u>N</u>	<u>\bar{X}</u>	<u>S. D.</u>	<u>14. Popliteal Ht (S)</u>	<u>N</u>	<u>\bar{X}</u>	<u>S. D.</u>
Sml Reg	59	47.51	1.80		72	38.76	1.57
Sml Lg	42	49.23	1.82		55	40.54	2.00
Lrg Reg	32	48.44	1.76		39	38.80	1.43
Lrg Lg	33	50.64	1.65		39	40.64	1.75
<u>15. Shoulder-Elbow L</u>				<u>16. Forearm-Hand L</u>			
Sml Reg	67	33.33	1.22		69	43.10	1.39
Sml Lg	55	34.72	1.38		56	44.84	1.30
Lrg Reg	36	33.93	1.12		38	43.81	1.32
Lrg Lg	38	35.54	1.22		38	45.52	1.38
<u>17. Biacromial Dia</u>				<u>18. Neck Circ</u>			
Sml Reg	30	36.68	1.59		78	35.44	1.26
Sml Lg	22	37.37	2.40		62	35.39	1.22
Lrg Reg	20	37.90	1.66		41	36.84	1.69
Lrg Lg	20	38.04	1.36		43	36.83	1.28
<u>19. Shoulder Circ</u>				<u>20. Chest Circ</u>			
Sml Reg	78	103.24	3.48		79	86.01	2.89
Sml Lg	63	103.94	3.60		64	86.36	2.98
Lrg Reg	41	107.84	3.70		41	90.74	3.04
Lrg Lg	43	107.57	3.50		43	89.89	3.25
<u>21. Waist Circ</u>				<u>22. Buttock Circ</u>			
Sml Reg	78	70.87	3.22		79	87.29	2.80
Sml Lg	64	71.36	3.75		64	88.17	3.14
Lrg Reg	41	76.18	5.93		41	91.67	2.90
Lrg Lg	43	75.51	4.54		43	92.01	2.66
<u>23. Thigh Circ</u>				<u>24. Lower Thigh C</u>			
Sml Reg	79	50.38	2.84		78	36.45	1.60
Sml Lg	64	50.59	3.28		63	36.16	1.78
Lrg Reg	40	54.17	2.91		40	38.80	1.85
Lrg Lg	42	53.38	3.25		43	38.70	1.61
<u>25. Calf Circ</u>				<u>26. Ankle Circ</u>			
Sml Reg	77	34.64	1.71		79	21.07	1.06
Sml Lg	64	34.71	1.73		64	21.31	1.24
Lrg Reg	40	36.63	1.67		41	21.97	.99
Lrg Lg	43	36.67	1.52		43	22.07	.90

** (S) Sitting.

TABLE 4 (Cont'd)

Means and Standard Deviations of Height-Weight Categories

<u>27. Scye Circ</u>	<u>N</u>	<u>\bar{X}</u>	<u>S. D.</u>	<u>28. Axillary Arm C</u>	<u>N</u>	<u>\bar{X}</u>	<u>S. D.</u>
Sml Reg	78	41.44	2.12		77	28.95	1.79
Sml Lg	63	41.57	2.04		63	28.56	2.23
Lrg Reg	40	43.28	1.77		40	30.47	1.60
Lrg Lg	39	43.30	2.05		43	29.97	2.00
<u>29. Biceps Circ (F)*</u>				<u>30. Elbow Circ (F)</u>			
Sml Reg	78	29.49	1.43		67	27.75	1.31
Sml Lg	64	29.37	1.46		57	27.73	1.36
Lrg Reg	39	31.30	1.42		38	29.05	1.18
Lrg Lg	43	30.65	1.26		34	29.02	1.34
<u>31. Forearm Circ (F)</u>				<u>32. Wrist Circ</u>			
Sml Reg	79	26.40	1.08		79	16.12	.53
Sml Lg	64	26.28	1.42		64	16.23	.67
Lrg Reg	41	27.75	1.06		40	16.91	.69
Lrg Lg	42	27.13	1.23		43	16.86	.56
<u>33. Sleeve Inseam</u>				<u>34. Sleeve Lgth</u>			
Sml Reg	48	44.19	2.13		40	77.89	3.20
Sml Lg	45	45.49	2.07		36	80.51	2.78
Lrg Reg	34	43.92	1.50		26	79.73	1.86
Lrg Lg	34	46.17	1.66		29	82.45	2.09
<u>35. Ant. Neck Lgth</u>				<u>36. Post Neck Lgth</u>			
Sml Reg	55	9.08	1.26		79	11.61	1.67
Sml Lg	43	9.63	1.18		64	12.30	1.62
Lrg Reg	36	8.85	1.42		41	11.80	1.42
Lrg Lg	37	9.55	1.30		43	11.94	1.90
<u>37. Shoulder Lgth</u>				<u>38. Waist Back</u>			
Sml Reg	55	15.88	1.62		78	43.36	2.52
Sml Lg	40	16.25	1.51		64	45.09	2.47
Lrg Reg	22	15.49	1.31		41	43.82	2.61
Lrg Lg	23	15.95	.98		43	44.76	2.76
<u>39. Waist Front</u>				<u>40. Crotch Lgth</u>			
Sml Reg	40	38.10	2.12		78	65.21	3.72
Sml Lg	31	39.52	2.38		63	67.14	4.45
Lrg Reg	12	39.77	2.36		41	67.84	3.77
Lrg Lg	14	40.06	1.75		41	69.74	4.10

* (F) Flexed.

TABLE 4

Means and Standard Deviations of Height-Weight Categories

<u>41. Vertical Trunk C</u>	<u>N</u>	<u>\bar{X}</u>	<u>S. D.</u>	<u>42. Interscye</u>	<u>N</u>	<u>\bar{X}</u>	<u>S. D.</u>
Sml Reg	76	152.37	5.20		78	36.67	2.31
Sml Lg	63	156.51	5.61		62	36.80	2.88
Lrg Reg	41	156.80	4.39		41	38.72	2.68
Lrg Lg	43	158.14	4.66		43	38.40	2.54
<u>43. Interscye Max</u>				<u>44. Buttock Circ (S)</u>			
Sml Reg	64	49.44	3.28		64	94.81	3.44
Sml Lg	44	49.35	3.21		47	96.36	4.01
Lrg Reg	26	52.25	3.79		26	100.07	4.67
Lrg Lg	35	51.47	3.75		35	99.91	3.51
<u>45. Knee Circ (S)</u>				<u>46. Medial Malleolus H</u>			
Sml Reg	79	36.21	1.79		59	8.41	.84
Sml Lg	64	36.33	1.82		51	8.71	.88
Lrg Reg	40	37.90	1.73		32	8.98	.68
Lrg Lg	41	38.75	1.87		33	8.78	.85

TABLE 5

CALCULATED DESIGN RANGES - JAPANESE DATA
Four-Size Height-Weight Sizing Program

<u>1. Weight *</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	50.0	61.9
Small Long	50.0	61.9
Large Regular	62.0	73.9
Large Long	62.0	73.9
<u>2. Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	156.0	165.9
Small Long	166.0	175.9
Large Regular	158.0	167.9
Large Long	168.0	177.9
<u>3. Cervicale Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	132.6	141.9
Small Long	138.5	147.8
Large Regular	134.6	143.9
Large Long	141.0	150.3
<u>4. Shoulder Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	128.4	136.9
Small Long	133.8	142.3
Large Regular	130.5	139.0
Large Long	136.0	144.5
<u>5. Suprasternale Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	127.0	135.2
Small Long	132.5	140.7
Large Regular	128.7	136.9
Large Long	135.0	143.2
<u>6. Substernale Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	109.2	118.4
Small Long	113.2	122.3
Large Regular	111.3	120.5
Large Long	155.5	124.7
<u>7. Nipple Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	112.9	120.7
Small Long	118.0	125.8
Large Regular	114.4	122.1
Large Long	119.8	127.6

* Weight in kilograms, all other dimensions in centimeters.

TABLE 5 (Cont'd)

CALCULATED DESIGN RANGES - JAPANESE DATA
Four-Size Height-Weight Sizing Program

<u>8. Elbow Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	98.0	105.7
Small Long	102.0	109.7
Large Regular	99.7	107.4
Large Long	103.8	111.5
<u>9. Waist Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	90.8	100.0
Small Long	95.7	104.8
Large Regular	92.3	101.4
Large Long	97.4	106.6
<u>10. Crotch Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	68.2	76.4
Small Long	71.6	79.8
Large Regular	68.7	76.9
Large Long	73.0	81.2
<u>11. Patella Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	43.0	48.2
Small Long	44.7	49.9
Large Regular	43.5	48.7
Large Long	46.2	51.4
<u>12. Sitting Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	85.7	91.9
Small Long	88.5	94.7
Large Regular	87.1	93.3
Large Long	89.6	95.9
<u>13. Knee Height, Sitting</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	44.9	50.2
Small Long	46.6	51.9
Large Regular	45.8	51.1
Large Long	48.0	53.3
<u>14. Popliteal Height, Sitting</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	36.2	41.3
Small Long	38.0	43.1
Large Regular	36.2	41.4
Large Long	38.1	43.2

TABLE 5 (Cont'd)

CALCULATED DESIGN RANGES - JAPANESE DATA
Four-Size Height-Weight Sizing Program

<u>15. Shoulder-Elbow Length</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	31.5	35.2
Small Long	32.8	36.6
Large Regular	32.1	35.8
Large Long	33.7	37.4
<u>16. Forearm-Hand Length</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	41.1	45.1
Small Long	42.8	46.9
Large Regular	41.8	45.8
Large Long	43.5	47.5
<u>17. Biacromial Diameter</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	34.0	39.4
Small Long	34.7	40.1
Large Regular	35.2	40.6
Large Long	35.4	40.7
<u>18. Neck Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	33.4	37.4
Small Long	33.4	37.4
Large Regular	34.8	38.8
Large Long	34.8	38.8
<u>19. Shoulder Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	97.9	108.6
Small Long	98.6	109.3
Large Regular	102.5	113.2
Large Long	102.2	112.9
<u>20. Chest Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	81.5	90.5
Small Long	81.8	90.9
Large Regular	86.2	95.3
Large Long	85.4	94.4
<u>21. Waist Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	64.5	77.2
Small Long	65.0	77.7
Large Regular	69.8	82.5
Large Long	69.2	81.8

TABLE 5 (Cont'd)

CALCULATED DESIGN RANGES - JAPANESE DATA
Four-Size Height-Weight Sizing Program

<u>22. Buttock Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	83.1	91.5
Small Long	83.9	92.4
Large Regular	87.4	95.9
Large Long	87.8	96.2
<u>23. Thigh Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	45.8	55.0
Small Long	46.0	55.2
Large Regular	49.6	58.8
Large Long	48.8	58.0
<u>24. Lower Thigh Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	33.9	39.0
Small Long	33.6	38.7
Large Regular	36.3	41.4
Large Long	36.2	41.3
<u>25. Calf Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	32.1	37.2
Small Long	32.2	37.2
Large Regular	34.1	39.2
Large Long	34.2	39.2
<u>26. Ankle Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	19.5	22.7
Small Long	19.7	22.9
Large Regular	20.4	23.6
Large Long	20.5	23.7
<u>27. Scye Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	38.4	44.5
Small Long	38.5	44.6
Large Regular	40.2	46.3
Large Long	40.3	46.4
<u>28. Axillary Arm Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	26.1	31.9
Small Long	25.7	31.5
Large Regular	27.6	33.4
Large Long	27.1	32.9

TABLE 5 (Cont'd)

CALCULATED DESIGN RANGES - JAPANESE DATA
Four-Size Height-Weight Sizing Program

<u>29. Biceps Circumference, Flexed</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	27.4	31.6
Small Long	27.3	31.5
Large Regular	29.2	33.4
Large Long	28.6	32.8
<u>30. Elbow Circumference, Flexed</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	25.8	29.7
Small Long	25.8	29.7
Large Regular	27.1	31.0
Large Long	27.0	31.0
<u>31. Forearm Circumference, Flexed</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	24.6	28.2
Small Long	24.5	28.1
Large Regular	25.9	29.6
Large Long	25.3	29.0
<u>32. Wrist Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	15.2	17.0
Small Long	15.3	17.2
Large Regular	16.0	17.8
Large Long	15.9	17.8
<u>33. Sleeve Inseam</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	41.3	47.1
Small Long	42.6	48.4
Large Regular	41.1	46.8
Large Long	43.3	49.0
<u>34. Sleeve Length</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	74.0	81.8
Small Long	76.6	84.4
Large Regular	75.8	83.7
Large Long	78.5	86.4
<u>35. Anterior Neck Length</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	7.2	11.0
Small Long	7.7	11.5
Large Regular	6.9	10.8
Large Long	7.6	11.5

TABLE 5 (Cont'd)

CALCULATED DESIGN RANGES - JAPANESE DATA
Four-Size Height-Weight Sizing Program

<u>36. Posterior Neck Length</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	9.1	14.1
Small Long	9.8	14.8
Large Regular	9.3	14.3
Large Long	9.4	14.5
<u>37. Shoulder Length</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	13.7	18.1
Small Long	14.1	18.4
Large Regular	13.3	17.7
Large Long	13.8	18.1
<u>38. Waist Back</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	39.5	47.2
Small Long	41.2	49.0
Large Regular	40.0	47.7
Large Long	40.9	48.6
<u>39. Waist Front</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	34.8	41.4
Small Long	36.3	42.8
Large Regular	36.5	43.0
Large Long	36.8	43.3
<u>40. Crotch Length</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	59.2	71.2
Small Long	61.1	73.2
Large Regular	61.8	73.9
Large Long	63.7	75.8
<u>41. Vertical Trunk Circumference</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	144.8	160.0
Small Long	148.9	164.1
Large Regular	149.2	164.4
Large Long	150.5	165.8
<u>42. Interscye</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	32.8	40.6
Small Long	32.9	40.7
Large Regular	34.8	42.6
Large Long	34.5	42.3

TABLE 5 (Cont'd)

CALCULATED DESIGN RANGES - JAPANESE DATA
Four-Size Height-Weight Sizing Program

<u>43. Interscye Maximum</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	44.3	54.6
Small Long	44.2	54.5
Large Regular	47.1	57.4
Large Long	46.3	56.7
<u>44. Buttock Circumference, Sitting</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	89.0	100.6
Small Long	90.6	102.2
Large Regular	94.3	105.9
Large Long	94.1	105.7
<u>45. Knee Circumference, Sitting</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	33.5	38.9
Small Long	33.6	39.0
Large Regular	35.2	40.6
Large Long	36.1	41.5
<u>46. Medial Malleolus Height</u>	<u>Minimum</u>	<u>Maximum</u>
Small Regular	7.2	9.6
Small Long	7.5	9.9
Large Regular	7.8	10.2
Large Long	7.6	10.0

FIT-TESTS AND RESULTS

The sizing program statistics were furnished to the David Clark Company, Worcester, Massachusetts, which had initially developed the CSU - 4/P Partial Pressure Assembly and the CWU - 12/P Exposure Assembly* for the United States Air Force. The David Clark Company then fabricated a prototype garment of each size.

These prototype garments were to be used to validate the success of the complete developmental program. A fit-test was planned to provide the investigators with sufficient information to evaluate objectively each aspect of the program, which included the anthropometric survey, the statistical analysis of the data, and the integration of the sizing data into the actual end item. Only after such a fit-test, or validation test, could the entire procedure be evaluated from the practical standpoint of how well the end item fits and protects the wearer.

The fabricated items were taken to Japan, and fit-tests were conducted, using 75 Japanese pilots at the air bases of Hamamatsu and Tachikawa. Of the 75 subjects tested, 69 (92 percent of the total) were fitted in their indicated Height-Weight size. The results of the fit-tests were as follows:

Overall Fitted	70 of 75	93.3%
Fitted in Indicated Size	69 of 75	92.0%
Upgraded Fit	1 of 75	1.3%
Not Fitted	5 of 75	6.6%

Distribution of Fitted Sizes

Small Regular	22
Small Long	15
Large Regular	15
Large Long	17

The one subject fitted by upgrading to a larger size had a very large Chest Circumference and the size of garment indicated from his Height and Weight was too constrictive in the chest area for comfort. Of the five pilots not fitted, two were above and one below the Weight range for the sizing program. Since the suits do stretch somewhat with use, the fitters believed that the two heavy pilots could have been fitted with garments that had been stretched with repeated use.

* The Japanese-sized version of the CWU - 12/P Exposure Assembly is now designated CSU - 13/P.

The pilot whose Weight fell below the Weight range was afforded high altitude protection even though the garment fitted loosely. Despite the protection afforded, the pilot was considered not to have been properly fitted. The two remaining pilots should have been fitted but were extremely heavy in the chest and abdominal areas for their Height and Weight and fitters were reluctant to stress the garment zippers.

The fact that five of the 75 pilots were not properly fitted was not considered unsatisfactory, as experience with other sizing programs indicates that it is almost impossible to design a program that will effectively fit an entire population. In most cases, sizing programs are designed to accommodate 90 to 95 percent of a given population. To fit the remaining small percent would require so many additional sizes and/or ranges of adjustability in garments that it has been found to be more effective and less expensive to provide these extremes of body size with tailor-made garments.

The CWU - 13/P Exposure Garment was tested in the same manner as above on 34 subjects. This garment, sized to fit over the CSU - 7/P Partial Pressure Assembly, was found to fit adequately in each case with no detrimental effect on mobility and comfort.

The type of information obtained during the fit-tests is illustrated in the data form (Figure 1). This form consists of three sections. The first contains a brief history for each subject and a series of selected body measurements. The body measurements were taken on each subject to obtain the information needed to determine his indicated suit size and to allow comparison of the fit-test sample with the original survey sample.

Section II of the data sheet contains a check list of critical areas of the body that influence comfort, mobility, and ballooning growth of suit during inflation of pressure suits. Both the CSU - 7/P and CWU 13/P Assemblies were evaluated in the pressurized and unpressurized states. Evaluations of fit were based on experience and the solicited comments of the subject.

Section III of the data form contains additional anthropometric measurements taken on those subjects who were judged to be improperly fitted. This section also contains space for general comments by both the evaluators and the subjects.

Figure 2 shows a general picture of the fit-tests being conducted at Tachikawa Air Base. Figure 3 indicates one of the methods used by the evaluator to determine the overall mobility of the pressurized CSU - 7/P Partial Pressure Assembly.

In addition to the fit-tests in which fit, comfort, ballooning, and mobility were evaluated, a number of subjects from the fit-test sample were given



Figure 2. General View of the Fit-Tests as Conducted at Tachikawa Air Base, Tokyo, Japan



Figure 3. Evaluation of Mobility of the CSU - 7/P Partial Pressure Assembly
(Photographs furnished by Col. T. Hagiwara, Aero Medical Laboratory, JASDF)

pressure-chamber flights. These flights included an explosive decompression to a simulated altitude of 75,000 feet. The garments were found to provide good physiological protection for the test subjects during these chamber flights.

The anthropometric statistics for the fit-test sample are given in Table 6. In general, it appears that the fit-test sample is closely comparable in body size to the survey sample on which the program was based. One major difference is in the age of the two groups. This difference and the greater standard deviations for most of the anthropometric dimensions suggest that the Japanese were attempting to include in the fit-tests as many subjects as possible that were extremes in their body dimensions.* A purely random sample of test subjects would in all probability have given a higher percentage of successful fittings.

One major difference between the two sets of data is that for the dimension of Biacromial Diameter. It would appear that there is a difference in measuring technique involved here which may be expected in this type of survey. The majority of the data in this table illustrates how closely the two samples match, despite the decided handicap under which the original survey data were gathered.

In Table 7 is shown a correlation matrix of the fit-test anthropometric data. These correlation coefficients compare closely with those for the USAF flying population of 1950 (unpublished data).

The initial analysis of the JASDF Anthropometric Survey data was carried out under a severe time limitation because of the anticipated early need for the protective flight gear. Because of the limited time available, only a minimum of effort could be allotted for editing and checking of the raw data. Since this time, a complete re-analysis has been carried out on 38 of the variables reported above, using a slightly smaller sample having complete data. The results of this re-analysis are given in Tables 8 and 9. The summary statistics of Table 8 indicate that few differences were found in the means and standard deviations of this analysis when compared with the data in Table 1. However, the correlation coefficients (Table 9) were considerably improved over those obtained in computing the multiple correlation coefficients (Table 2) and are very similar to the values computed for the USAF population (unpublished data).

* Col. Hagiwara, Physiological Training Officer, JASDF, who coordinated the fit-tests, indicated in a conversation following the test that the fit-test sample was not selected purely at random but that some 16 individuals had been selected on the bases of extremes in body size, to be included in the test sample.

TABLE 6

Comparison of Fit-Test and Survey Anthropometric Statistics

	Fit-Test Data*		Survey Data**	
	Mean (Sex̄)	S. D. (Se _r)	Mean (Sex̄)	S. D. (Se _r)
Age***	29.29 (0.70)	6.08 (0.50)	24.14 (0.30)	4.36 (0.20)
Weight	62.17 (0.84)	7.27 (0.59)	61.09 (0.39)	6.05 (0.28)
Height	166.86 (0.62)	5.41 (0.44)	166.71 (0.31)	4.86 (0.22)
Biacromial Diameter	39.05 (0.19)	1.61 (0.13)	37.34 (0.19)	1.90 (0.14)
Hip Breadth	31.82 (0.15)	1.29 (0.11)	(Not taken in Survey)	
Chest Circumference	88.00 (0.55)	4.74 (0.39)	87.94 (0.25)	3.93 (0.18)
Buttock Circumference	89.59 (0.47)	4.09 (0.33)	89.48 (0.25)	3.84 (0.18)
Thigh Circumference	52.73 (0.40)	3.51 (0.29)	51.84 (0.23)	3.60 (0.16)
Sleeve Length	80.19 (0.32)	2.80 (0.23)	80.28 (0.28)	3.26 (0.20)
Sitting Height	91.75 (0.31)	2.69 (0.22)	90.63 (0.17)	2.66 (0.12)
Crotch Height	75.08 (0.39)	3.35 (0.27)	74.35 (0.23)	3.54 (0.16)

TABLE 7

Inter-Correlation Coefficients of Fit-Test Anthropometry

	1	2	3	4	5	6	7	8	9	10
1 Weight	-									
2 Height	0.461	-								
3 Biacromial Dia	0.525	0.426	-							
4 Hip Br	0.748	0.573	0.471	-						
5 Chest Circ	0.876	0.246	0.468	0.642	-					
6 Buttock Circ	0.919	0.379	0.480	0.790	0.804	-				
7 Thigh Circ	0.881	0.228	0.446	0.675	0.790	0.878	-			
8 Sleeve Lgth	0.474	0.810	0.501	0.543	0.341	0.385	0.291	-		
9 Sitting Ht	0.558	0.870	0.430	0.573	0.319	0.527	0.365	0.617	-	
10 Crotch Ht	0.214	0.870	0.309	0.410	0.068	0.120	-0.007	0.772	0.584	-

* Number of fit-test sample is 75.

** Number of survey sample is 239.

*** Age in years, weight in kilograms, body measurements in centimeters.

TABLE 8

Re-Analysis of JASDF Anthropometric Survey Data

	<u>Mean</u>	<u>SE\bar{x}</u>	<u>S. D.</u>	<u>SEσ</u>	<u>CV</u>
Weight*	60.85	0.37	5.59	0.26	9.19
Height	166.69	0.32	4.85	0.22	2.91
Cervicale Ht	141.04	0.32	4.83	0.22	3.42
Substernale Ht	116.59	0.27	4.19	0.19	3.59
Nipple Ht	119.96	0.27	4.09	0.19	3.41
Elbow Ht	104.43	0.24	3.73	0.17	3.57
Waist Ht	98.26	0.29	4.35	0.20	4.43
Crotch Ht	74.29	0.23	3.55	0.16	4.78
Patella Ht	46.87	0.14	2.20	0.10	4.69
Sitting Ht	90.67	0.16	2.46	0.11	2.71
Neck Circ	35.98	0.10	1.54	0.07	4.28
Shoulder Circ	105.20	0.26	3.98	0.18	3.78
Chest Circ	87.67	0.24	3.71	0.17	4.23
Waist Circ	73.05	0.33	5.05	0.23	6.91
Buttock Circ	89.29	0.24	3.62	0.17	4.05
Thigh Circ	51.78	0.22	3.34	0.15	6.45
Lower Thigh Circ	37.20	0.14	2.11	0.10	5.67
Calf Circ	35.52	0.13	1.98	0.09	5.57
Ankle Circ	21.42	0.06	0.97	0.05	4.53
Scye Circ	42.23	0.15	2.25	0.10	5.33
Axillary Arm Circ	29.33	0.14	2.06	0.10	7.02
Biceps Circ	30.02	0.11	1.65	0.08	5.50
Forearm Circ	26.77	0.09	1.34	0.06	5.00
Wrist Circ	16.44	0.04	0.68	0.03	4.14
Waist Back	44.22	0.18	2.70	0.12	6.10
Crotch Lgth	67.06	0.29	4.36	0.20	6.50
Vertical Trunk Circ	155.59	0.37	5.64	0.26	3.62
Interscye	37.42	0.18	2.73	0.13	7.30
Knee Circ (S)	37.05	0.14	2.09	0.10	5.64
Hand Lgth	18.25	0.05	0.79	0.04	4.33
Hand Br	8.56	0.03	0.52	0.02	6.07
Hand Circ	21.13	0.07	1.07	0.05	5.06
Head Lgth	18.61	0.05	0.76	0.04	4.08
Head Br	15.72	0.04	0.58	0.03	3.69
Bigonial Br	11.74	0.05	0.76	0.04	6.47
Menton-Nasion Lgth	12.03	0.04	0.57	0.03	4.74
Lip Lgth	5.07	0.03	0.43	0.02	8.48
Head Circ	56.21	0.08	1.22	0.06	2.17

* Weight in kilograms, all other dimensions in centimeters. The N used in this analysis was 233.

TABLE 9
SELECTED JASDF CORRELATION COEFFICIENTS

	1	2	3	6	7	8	9	10	11	12	18	19	20
1 WEIGHT	0.436	0.436	0.410	0.399	0.361	0.372	0.347	0.253	0.321	0.339	0.557	0.666	0.720
2 HEIGHT	0.410	0.945	0.945	0.843	0.911	0.840	0.798	0.765	0.722	0.747	0.070	0.212	0.222
3 CERVICALE HEIGHT	0.399	0.843	0.847	0.887	0.887	0.784	0.770	0.730	0.657	0.592	-0.027	0.158	0.221
6 SUBSTERNALE HT.	0.361	0.911	0.905	0.820	0.811	0.835	0.817	0.774	0.718	0.632	0.046	0.149	0.150
7 NIPPLE HEIGHT	0.392	0.843	0.820	0.770	0.770	0.745	0.745	0.715	0.659	0.625	0.090	0.146	0.162
8 ELBOW HEIGHT	0.347	0.796	0.811	0.784	0.817	0.715	0.729	0.729	0.730	0.382	0.047	0.110	0.164
9 WAIST HEIGHT	0.253	0.765	0.770	0.730	0.774	0.671	0.659	0.730	0.730	0.382	0.144	0.139	0.231
10 CROTCH HEIGHT	0.321	0.722	0.728	0.657	0.718	0.625	0.572	0.388	0.382	0.032	0.032	0.163	0.091
11 PATELLA HEIGHT	0.339	0.747	0.673	0.592	0.632	0.090	-0.020	0.047	0.144	0.032	0.543	0.543	0.565
12 SITTING HEIGHT	0.557	0.070	0.046	-0.027	0.003	0.090	-0.020	0.047	0.144	0.032	0.543	0.543	0.627
18 NECK CIRCUMFERENCE	0.666	0.212	0.158	0.149	0.162	0.164	0.115	0.164	0.231	0.091	0.585	0.627	0.673
19 SHOULDER CIRC.	0.720	0.222	0.221	0.150	0.162	0.164	0.115	0.164	0.231	0.091	0.585	0.627	0.688
20 CHEST CIRC.	0.666	0.109	0.122	0.033	0.075	0.093	0.020	0.006	0.154	0.029	0.550	0.572	0.619
21 WAIST CIRC.	0.806	0.334	0.331	0.262	0.264	0.322	0.196	0.147	0.248	0.306	0.570	0.556	0.619
22 BUTTOCK CIRC.	0.702	0.150	0.170	0.140	0.123	0.146	0.075	0.043	0.146	0.101	0.551	0.480	0.471
23 THIGH CIRC.	0.691	0.177	0.156	0.179	0.125	0.176	0.093	0.057	0.107	0.175	0.402	0.455	0.505
24 LOWER THIGH C.	0.695	0.140	0.123	0.135	0.119	0.148	0.099	0.096	0.095	0.041	0.396	0.453	0.505
25 CALF CIRCUMFERENCE	0.662	0.321	0.312	0.282	0.281	0.319	0.203	0.201	0.241	0.219	0.373	0.394	0.475
26 ANKLE CIRC.	0.499	0.163	0.147	0.153	0.153	0.214	0.150	0.179	0.214	0.084	0.384	0.424	0.441
27 SCYE CIRCUMFERENCE	0.500	0.091	0.038	0.042	0.021	0.040	0.010	-0.008	0.114	-0.032	0.421	0.381	0.507
28 AXILLARY ARM C.	0.631	0.096	0.108	0.121	0.076	0.132	0.064	0.027	0.098	0.111	0.479	0.486	0.566
29 BICEPS CIRC.	0.636	0.077	0.075	0.123	0.045	0.081	0.055	-0.025	0.098	0.079	0.466	0.490	0.519
31 FOREARM CIRC.	0.630	0.252	0.204	0.168	0.209	0.265	0.114	0.173	0.189	0.220	0.511	0.508	0.445
32 WRIST CIRC.	0.174	0.380	0.399	0.239	0.303	0.350	0.121	0.223	0.138	0.347	0.070	0.180	0.207
38 WAIST BACK	0.370	0.333	0.346	0.343	0.315	0.294	0.437	0.147	0.278	0.358	0.127	0.262	0.228
40 CROTCH LENGTH	0.495	0.494	0.478	0.405	0.434	0.469	0.324	0.193	0.286	0.511	0.303	0.355	0.397
41 VERT. TRUNK C.	0.326	0.110	0.089	0.050	0.035	0.065	0.034	0.130	0.103	0.028	0.250	0.345	0.438
42 INTERSCYE	0.587	0.330	0.347	0.357	0.312	0.317	0.296	0.162	0.285	0.286	0.298	0.234	0.438
45 KNEE CIRC/SITTING	0.318	0.566	0.559	0.515	0.530	0.523	0.461	0.516	0.444	0.411	0.072	0.140	0.139
47 HAND LENGTH	0.234	0.160	0.132	0.194	0.159	0.124	-0.015	0.097	0.017	0.098	0.027	0.136	0.105
48 HAND BREADTH	0.374	0.182	0.152	0.211	0.140	0.147	0.046	0.098	0.080	0.174	0.128	0.172	0.255
49 HAND CIRCUMFERENCE	0.254	0.102	0.054	0.106	0.029	0.051	0.133	-0.028	-0.030	0.186	0.201	0.293	0.139
50 HEAD LENGTH	0.202	0.116	0.060	0.071	0.028	0.010	0.034	-0.027	0.019	0.195	0.129	0.014	0.036
51 HEAD BREADTH	0.231	0.081	0.027	-0.043	-0.021	-0.042	-0.052	-0.057	-0.021	0.185	0.280	0.203	0.210
53 BIGNIAL DIAMETER	0.249	0.204	0.164	0.170	0.134	0.092	0.076	0.091	0.113	0.163	0.185	0.241	0.173
58 MENTON-NASION	0.150	0.145	0.110	0.009	0.102	0.116	0.026	0.100	0.218	0.096	0.318	0.272	0.305
59 LIP LENGTH	0.362	0.163	0.113	0.136	0.101	0.121	0.152	0.114	0.144	0.214	0.377	0.256	0.297
60 HEAD CIRCUMFERENCE													

TABLE 9 (Cont'd)
SELECTED JASDF CORRELATION COEFFICIENTS

	21	22	23	24	25	26	27	28	29	31	32	38	40
1 WEIGHT	0.666	0.806	0.702	0.691	0.695	0.662	0.499	0.500	0.631	0.636	0.630	0.174	0.370
2 HEIGHT	0.109	0.334	0.150	0.177	0.140	0.321	0.163	0.001	0.096	0.077	0.252	0.380	0.333
3 CERVICALE HEIGHT	0.122	0.331	0.170	0.156	0.123	0.312	0.147	0.038	0.108	0.075	0.204	0.399	0.346
6 SUBSTERNAL HT.	0.033	0.262	0.140	0.179	0.135	0.282	0.153	0.042	0.121	0.123	0.168	0.239	0.343
7 NIPPLE HEIGHT	0.075	0.264	0.123	0.125	0.119	0.281	0.153	0.021	0.076	0.045	0.209	0.303	0.315
8 ELBOW HEIGHT	0.093	0.322	0.146	0.176	0.148	0.319	0.214	0.040	0.132	0.081	0.265	0.350	0.294
9 WAIST HEIGHT	0.020	0.196	0.075	0.093	0.099	0.203	0.150	0.010	0.064	0.055	0.114	0.121	0.437
10 CROTCH HEIGHT	0.006	0.147	0.043	0.057	0.096	0.201	0.179	-0.008	0.027	-0.025	0.173	0.223	0.147
11 PATELLA HEIGHT	0.154	0.248	0.146	0.107	0.095	0.241	0.214	0.114	0.098	0.098	0.189	0.138	0.278
12 SITTING HEIGHT	0.029	0.306	0.101	0.175	0.041	0.219	0.084	-0.032	0.111	0.079	0.220	0.347	0.358
18 NECK CIRCUMF'CE	0.550	0.570	0.551	0.402	0.396	0.373	0.384	0.421	0.479	0.466	0.511	0.070	0.127
19 SHOULDER CIRC.	0.512	0.556	0.480	0.455	0.453	0.394	0.424	0.381	0.486	0.490	0.508	0.180	0.262
20 CHEST CIRC.	0.673	0.688	0.619	0.471	0.505	0.475	0.441	0.507	0.566	0.519	0.445	0.207	0.228
21 WAIST CIRC.	0.702	0.702	0.642	0.523	0.486	0.396	0.523	0.471	0.449	0.462	0.448	0.188	0.176
22 BUTTUCK CIRC.	0.702	0.688	0.642	0.629	0.621	0.631	0.531	0.566	0.627	0.537	0.594	0.254	0.295
23 THIGH CIRC.	0.642	0.818	0.818	0.608	0.621	0.567	0.472	0.640	0.641	0.553	0.462	0.072	0.218
24 LOWER THIGH C.	0.523	0.629	0.608	0.602	0.602	0.581	0.440	0.460	0.482	0.404	0.540	0.118	0.152
25 CALF CIRCUMF'CE	0.486	0.621	0.621	0.591	0.584	0.684	0.403	0.509	0.563	0.512	0.533	0.070	0.179
26 ANKLE CIRC.	0.396	0.631	0.567	0.440	0.403	0.336	0.336	0.403	0.543	0.514	0.654	0.147	0.200
27 SCYE CIRCUMF'CE	0.523	0.531	0.472	0.440	0.403	0.336	0.403	0.403	0.475	0.382	0.414	0.073	0.066
28 AXILLARY ARM C.	0.471	0.566	0.640	0.460	0.509	0.480	0.403	0.509	0.722	0.631	0.398	-0.034	0.153
29 BICEPS CIRC.	0.449	0.627	0.641	0.482	0.563	0.543	0.475	0.382	0.757	0.757	0.531	0.086	0.204
31 FOREARM CIRC.	0.462	0.537	0.553	0.404	0.512	0.514	0.382	0.480	0.722	0.631	0.508	-0.039	0.252
32 WRIST CIRC.	0.448	0.594	0.462	0.540	0.533	0.654	0.414	0.403	0.757	0.531	0.508	0.208	0.098
38 WAIST BACK	0.188	0.254	0.072	0.118	0.070	0.147	0.073	0.398	0.531	0.508	0.208	-0.099	-0.099
40 CROTCH LENGTH	0.176	0.295	0.218	0.152	0.179	0.200	0.066	0.153	0.204	0.252	0.098	0.414	0.426
41 VERT. TRUNK C.	0.461	0.569	0.453	0.288	0.293	0.405	0.239	0.196	0.316	0.349	0.365	0.094	0.112
42 INTERSCYE	0.207	0.253	0.196	0.154	0.231	0.183	0.149	0.183	0.266	0.148	0.142	0.094	0.377
45 KNEE CIRC/SIT'G	0.388	0.574	0.586	0.531	0.505	0.589	0.320	0.532	0.520	0.553	0.375	-0.017	0.158
47 HAND LENGTH	0.073	0.136	0.042	0.164	0.111	0.272	0.169	0.009	0.138	0.142	0.253	0.235	0.158
48 HAND BREADTH	-0.015	0.152	0.131	0.199	0.282	0.361	0.112	0.033	0.259	0.283	0.331	0.195	-0.105
49 HAND CIRCUMF'CE	0.064	0.305	0.282	0.283	0.390	0.410	0.164	0.261	0.422	0.464	0.367	0.170	0.060
50 HEAD LENGTH	0.078	0.084	0.058	0.181	0.089	0.071	0.094	-0.037	0.076	0.195	0.110	-0.119	0.259
51 HEAD BREADTH	0.015	0.056	0.053	0.075	0.031	0.065	-0.070	-0.070	0.077	0.077	-0.015	-0.040	0.139
53 BIGONIAL DIAMETER	0.208	0.242	0.168	0.204	0.180	0.226	0.204	0.043	0.239	0.208	0.291	0.117	-0.008
58 MENTON-MASION	0.167	0.121	0.069	0.154	0.101	0.171	0.044	-0.037	0.068	0.097	0.116	0.189	0.106
59 LIP LENGTH	0.311	0.208	0.151	0.031	0.008	0.110	0.176	0.085	0.011	0.120	0.225	0.172	0.024
60 HEAD CIRCUMF'CE	0.167	0.297	0.294	0.248	0.260	0.202	0.137	0.110	0.153	0.210	0.231	-0.019	0.224

TABLE 9 (Cont'd)
SELECTED JASDF CORRELATION COEFFICIENTS

1	WEIGHT	41	42	45	47	48	49	50	51	53	58	59	60
2	HEIGHT	0.495	0.326	0.587	0.318	0.234	0.374	0.254	0.202	0.231	0.249	0.150	0.362
3	CERVICALE H'GHT	0.494	0.110	0.330	0.566	0.160	0.182	0.102	0.116	0.081	0.204	0.145	0.163
6	SUBSTERNALE HT.	0.478	0.089	0.347	0.559	0.132	0.152	0.054	0.060	0.027	0.164	0.110	0.113
7	NIPPLE HEIGHT	0.405	0.050	0.357	0.515	0.194	0.211	0.106	0.071	-0.043	0.170	0.009	0.136
8	ELBOW HEIGHT	0.434	0.035	0.312	0.530	0.159	0.140	0.029	0.028	-0.021	0.134	0.102	0.101
9	WAIST HEIGHT	0.469	0.065	0.317	0.523	0.124	0.147	0.051	0.010	-0.042	0.092	0.116	0.121
10	CROTCH HEIGHT	0.324	0.034	0.296	0.461	-0.015	0.046	0.133	0.034	-0.052	0.076	0.026	0.152
11	PATELLA HEIGHT	0.193	0.130	0.162	0.516	0.097	0.098	-0.028	-0.027	-0.057	0.091	0.100	0.114
12	SITTING HEIGHT	0.286	0.103	0.285	0.444	0.017	0.080	-0.030	-0.019	-0.021	0.113	0.218	0.144
18	NECK CIRCUMF'CE	0.511	0.028	0.286	0.411	0.098	0.174	0.186	0.195	0.185	0.163	0.096	0.214
19	SHOULDER CIRC.	0.303	0.250	0.298	0.072	0.027	0.128	0.201	0.129	0.260	0.185	0.318	0.377
20	CHEST CIRC.	0.355	0.345	0.234	0.140	0.136	0.172	0.293	0.014	0.203	0.241	0.272	0.256
21	WAIST CIRC.	0.397	0.438	0.438	0.139	0.105	0.255	0.139	0.036	0.210	0.173	0.305	0.297
22	BUTTOCK CIRC.	0.461	0.207	0.388	0.073	-0.015	0.064	0.078	0.015	0.208	0.167	0.311	0.167
23	THIGH CIRC.	0.569	0.258	0.574	0.196	0.152	0.305	0.084	0.058	0.242	0.121	0.208	0.297
24	LOWER THIGH C.	0.453	0.196	0.586	0.042	0.131	0.282	0.058	0.053	0.168	0.069	0.151	0.294
25	CALF CIRCUMF'CE	0.288	0.154	0.531	0.164	0.199	0.283	0.181	0.075	0.204	0.154	0.031	0.248
26	ANKLE CIRC.	0.293	0.231	0.505	0.111	0.282	0.390	0.089	0.031	0.180	0.101	0.008	0.260
27	SCYE CIRCUMF'CE	0.405	0.183	0.589	0.272	0.361	0.410	0.071	0.065	0.226	0.171	0.110	0.202
28	AXILLARY ARM C.	0.239	0.149	0.320	0.169	0.112	0.164	0.094	-0.070	0.204	0.044	0.176	0.137
29	BICEPS CIRC.	0.196	0.183	0.532	0.009	0.033	0.261	-0.037	-0.070	0.043	-0.037	0.085	0.110
31	FOREARM CIRC.	0.316	0.266	0.520	0.138	0.239	0.422	0.076	-0.075	0.239	0.068	0.011	0.153
32	WRIST CIRC.	0.349	0.143	0.553	0.142	0.283	0.464	0.195	0.077	0.208	0.097	0.120	0.210
38	WAIST BACK	0.365	0.142	0.375	0.253	0.331	0.367	0.110	-0.015	0.291	0.116	0.225	0.231
40	CROTCH LENGTH	0.414	0.094	-0.017	0.235	0.195	0.170	-0.119	-0.040	0.117	0.189	0.172	-0.019
41	VERT. TRUNK C.	0.426	0.112	0.377	0.158	-0.105	0.060	0.259	0.139	-0.008	0.106	0.024	0.224
42	INTERSCYE	0.062	0.062	0.418	0.135	0.082	0.186	0.069	0.071	0.162	0.171	0.275	0.202
45	KNEE CIRC/SIT'G	0.418	0.088	0.088	0.152	0.117	0.182	0.123	0.067	0.154	0.138	0.119	0.223
47	HAND LENGTH	0.185	0.152	0.153	0.117	0.153	0.289	0.094	0.083	0.137	0.086	0.052	0.301
48	HAND BREADTH	0.082	0.117	0.289	0.266	0.345	0.266	0.113	0.104	0.111	0.191	0.073	0.125
49	HAND CIRCUMF'CE	0.186	0.182	0.094	0.113	0.082	0.691	0.026	-0.016	0.145	0.084	-0.024	0.304
50	HEAD LENGTH	0.069	0.123	0.083	0.104	-0.016	0.013	0.127	0.013	0.063	0.062	-0.038	0.052
51	HEAD BREADTH	0.071	0.067	0.083	0.104	0.016	0.026	0.127	0.127	0.111	0.198	0.039	0.533
53	BIGONIAL DIAM'R	0.162	0.154	0.137	0.111	0.145	0.063	0.111	0.234	0.120	0.064	0.090	0.304
58	MENTON-NASION	0.171	0.138	0.088	0.191	0.094	0.062	0.198	0.120	0.064	0.064	0.272	0.251
59	LIP LENGTH	0.275	0.119	0.052	0.073	-0.024	-0.038	0.039	0.090	0.272	0.089	0.089	0.175
60	HEAD CIRCUMF'CE	0.202	0.223	0.301	0.125	0.004	0.052	0.533	0.304	0.251	0.175	0.183	

SUMMARY AND CONCLUSION

This report describes the development of a Japanese Air Self-Defense Force Height-Weight sizing program for protective flight garments. The program was carried out jointly by members of the Aeromedical Laboratory in Japan, and members of the Aerospace Medical Research Laboratories. Anthropometric data gathered by the Japanese were analysed in the Anthropology Research Project, Antioch College, and sizing programs were developed. Prototype garments were built to the four-size Height-Weight program by the David Clark Company, Worcester, Massachusetts. These garments were taken to Japan and fit-tests were conducted. The results of the fit-tests were considered satisfactory with 93 percent of the subjects being properly fitted in the CSU - 7/P Partial Pressure Assembly and CWU - 13/P Exposure Garment.

This research emphasizes the fact that the Height-Weight sizing system, developed and used extensively for protective flight clothing in the USAF, can be used successfully for other populations. The size categories must, however, be based upon an adequate knowledge of the body-size variability of the population under consideration.

BIBLIOGRAPHY

1. Emanuel, I. and M. Alexander, Height-Weight Sizing and Fit-Test of a Cutaway "G" Suit, Type CSU - 3/P, WADC Technical Report 57 - 432, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1957.
2. Emanuel, I., M. Alexander, E. Churchill, and B. Truett, A Height-Weight Sizing System for Flight Clothing, WADC Technical Report 56 - 365, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1959.
3. Hertzberg, H. T. E., G. S. Daniels, and E. Churchill, Anthropometry of Flying Personnel - 1950, WADC Technical Report 52 - 321, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1954.
4. Kay, Won Chuel, "Anthropometry of the ROKAF Pilots," Republic of Korea, Journal of Aviation Medicine, Vol. 9, No. 1, December, 1961.
5. McConville, J. T., and M. Alexander, Anthropometric Data in Three-Dimensional Form: Development and Fabrication of USAF Height-Weight Manikins, AMRL Technical Documentary Report 63 - 55, 6570th Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, 1963.
6. Morant, G. M., and J. C. Gilson, A Report of Body and Clothing Measurements of Royal Air Force Personnel, Flying Personnel Research Committee Report 633 (a), RAF Institute of Aviation Medicine, Farnborough, England, 1945.
7. Newman, R. W., and R. M. White, Reference Anthropometry of Army Men, Environmental Protection Section Report No. 180, Quartermaster Climatic Research Laboratory, Lawrence, Massachusetts, 1951.
8. O'Brien, R., M. A. Girshick, and E. P. Hunt, Body Measurements of American Boys and Girls for Garment and Pattern Construction, Miscellaneous Publication No. 366, U.S. Department of Agriculture, Washington, D. C., 1941.
9. Oshima, M., T. Fujimoto, T. Oguro, N. Tobimatsu, T. Mori, I. Tanaka, T. Watanabe, and M. Alexander, "Anthropometry of Japanese Pilot," The Reports of the Aero-Medical Laboratory, Vol. 2, No. 2, March, 1962.

BIBLIOGRAPHY (CONT'D)

10. Randall, F. E., Anthropometric Nomograph of Army Men, Environmental Protection Section Report No. 147, Quartermaster Climatic Research Laboratory, Lawrence, Massachusetts.
11. _____, Applications of Anthropometry to the Determination of Size in Clothing, Environmental Protection Series, Report No. 133, Quartermaster Climatic Research Laboratory, Lawrence, Massachusetts, 1948.
12. White, R. M., and G. Winston, A Nine-Size System for Functional Clothing, Special Report Number 50, Environmental Protection Section, Quartermaster Climatic Research Laboratory, Lawrence, Massachusetts, 1951.